The location of an electron in an atom can be described by four quantum numbers.

|  |  |  |
| --- | --- | --- |
| Quantum Number | Symbol | Range |
| Principal Quantum Number | n | n = 1 to n = ∞ |
| Angular Quantum Number | l | l = 0 to l =n – 1 |
| Magnetic Quantum Number | ml or sometimes just m | ml = - l to ml = + l |
| Spin Quantum Number | ms or sometimes just s | ms = + ½ or ms = - ½ |

ENERGY LEVELS (1, 2, 3, 4…) or SHELLS (K, L, M, N)

Are subdivided into

SUBLEVELS (s, p, d, f…) or SUBSHELLS

Which are subdivided into

ORBITALS

Bohr’s theory was based on the idea that electrons travel in some kind of **orbit** or path. A more modern view is that of an electron **orbital**. An electron orbital is a *region (volume) of space where an electron is most likely to be found*. Below is a table that indicates some of the differences between an orbit and an orbital.

|  |  |
| --- | --- |
| **Orbits** | **Orbitals** |
| 2-D path | 3-D region in space |
| Fixed distance from nucleus | Variable distance from nucleus |
| Circular or elliptical path | No path; varied shape of region |
| 2n2 electrons per orbit, where n is the principal quantum number | 2 electrons per orbital max |

Principal Quantum Number, n

This refers to the energy level. Energy levels range from n = 1 to n = ∞. As n increases, the energies of the orbitals also increase.

Secondary Quantum Number, l

This refers to the type of sublevel/subshell. Each subshell has a different shape. Subshells range from

l = 0 to l =n – 1.

value of l 0 1 2 3 4 5 …

letter designation s p d f g h

for subshells

(i.e., type of orbital)

Sketch of

orbital shape

Magnetic Quantum Number ml

This refers to the region of space in which electrons in the energy subshells are most likely to be found. Magnetic quantum number can range from ml= - l to ml = + l

value of 0 1 2 3 …

subshell s p d f …

# of orbitals

in sublevel 1 3 5 7

Spin Quantum Number ms

This is best described as the spin of the electrons in an orbital, although scientists do not think the electron is actually spinning. The spin quantum number can only be ms = + ½ or ms = - ½. Only two electrons can share the same orbital. You can think of it as one electron spinning clockwise and the other spinning counterclockwise.

**Problems**

Are the following sets of quantum numbers allowed? If yes, write “correct.” If no, explain what is wrong with each set.

* 1. n = 5, = 2, m = 2, s = +½
  2. n = 1, = 2, m = 0, s = -½
  3. n = 3, = 0, m = +1, s = +½
  4. n = 2, = 1, m = -1, s = +½
  5. n = 8, = 5, m = 6, s = +½

Relating Quantum numbers to atomic structure:

* n2 gives the maximum number of orbitals in energy level n
* The maximum number of electrons in an energy level can be determined using the formula 2n2.
* The number of subshells is equal to the principal quantum number.

For instance,

when n = 1, l = 0, therefore 1 subshell (s) [Refer to chart above.]

when n = 2, l = 0, 1, therefore 2 subshells (s, p)

When l =0, ml = 0; therefore the s subshell has only one orbital.

When l = 1, ml = -1, 0, +1; therefore the p subshell has three orbitals.

**Question 1:** Which sublevel has the following quantum numbers?

(a) n = 2, l =1 \_\_\_\_\_\_\_\_\_\_\_\_\_

(b) n = 3, l = 2 \_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 2:** What sublevels can be found in the following shells?

1. n = 3
2. n = 4

**Question 3:** How many orbitals are allowed in a g sublevel?

Question 4: What is the maximum number of orbitals permitted in energy level 3?

Question 5: What is the maximum number of electrons permitted in energy level 4?

Question 6: What is the maximum number of sublevels (types of orbitals) in energy level 5?